

ELECTRONIC FUNDAMENTALS

SERVICE PRACTICES 24

PHONO PLAYERS AND PICKUPS

- 24-1. The Modern Phonograph
- 24-2. Piezoelectric Pickups
- 24-3. Magnetic Reluctance Pickups
- 24-4. The Stylus
- 24-5. The Radio-Phonograph
Combination
- 24-6. Servicing the Radio-Phonograph



RCA INSTITUTES, INC.
A SERVICE OF RADIO CORPORATION OF AMERICA
HOME STUDY SCHOOL
350 West 4th Street, New York 14, N. Y.

Service Practices 24

INTRODUCTION

The old-time mechanical phonograph was a simple device compared with the modern phonograph. Figure 24-1 shows a phonograph that was popular thirty or forty years ago. This phonograph had three major parts: a hand-wound spring-driven motor, a pickup, and a horn. Either cylindrical or disk-shaped records were used.

The disk-shaped record rested upon a motor-driven rotating turntable. A spiral groove in the record wound round and round from the outside of the record to the center of the record. A needle, mounted in the pickup head, was placed in the groove and, as the record spun, the needle followed the groove from the outside to the center of the record. The needle was caused to vibrate as it moved along the uneven walls of the groove. The vibrating needle caused a drum to vibrate, and the vibrating drum caused the air to vibrate in a pattern that corresponded to the pattern of vibration of the needle. The vibrating air, which is sound, was funneled through the horn to the listener's ear. No amplifier tubes were used and there was no loudspeaker. The mechanical system is still in use today in portable machines for use where no electric power is available.

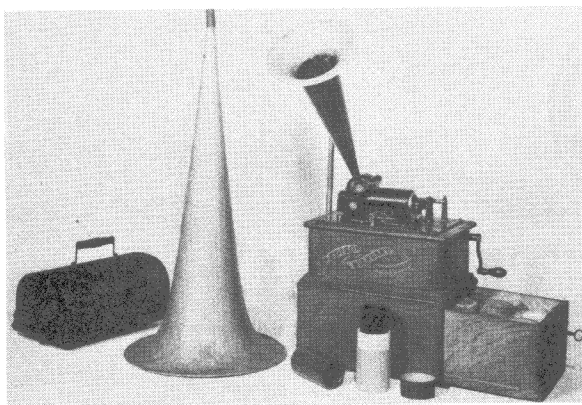


Fig. 24-1

Figure 24-2 is a symbolic diagram of the mechanical phonograph pickup and horn. The needle is attached, through a lever arm, to the center of a drum mounted inside the pickup.

From the pickup's drum, sound vibrations in the air funnel out through the horn — the ripples of the vibrating air getting bigger as the diameter of the horn gets bigger. Were it not for the horn, the ripples in the air would get still bigger. The farther they get from the drum, the bigger they get. However, the horn confines the ripples and concentrates their power. When sound comes from the horn, it is louder than it would be if there were no horn.

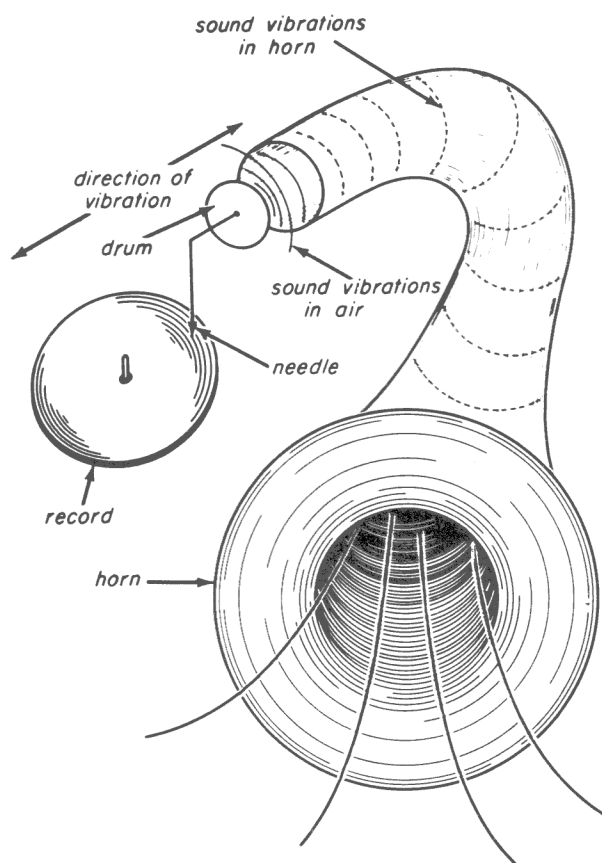


Fig. 24-2



Fig. 24-3

24-1. THE MODERN PHONOGRAPH

A modern electric phonograph is shown in Fig. 24-3. Electric phonographs have a pickup and a motor. The electronic amplifier and speaker take the place of the mechanical system's horn. Figure 24-4a is a diagram of an electric phonograph.

The purpose of an electrical pickup is to change the mechanical vibrations of the needle to electric vibrations — an audio signal. Unlike a mechanical pickup, an electrical pickup does not change the vibrations of the needle directly to sound vibration in air. In the electrical system, it is the loudspeaker that sets the air vibrating to the

rhythm of the recorded sound. The speaker converts the electrical vibrations of the audio signal to sound vibrations in air. The audio signal starts at the electrical pickup. It passes through an amplifier in order to be strengthened before it reaches the speaker, where it is converted to sound vibrations in air. A schematic diagram of an electric phonograph is shown in Fig. 24-4b.

24-2. PIEZOELECTRIC PICKUPS

The function of an electrical phonograph pickup is to generate an electric signal that

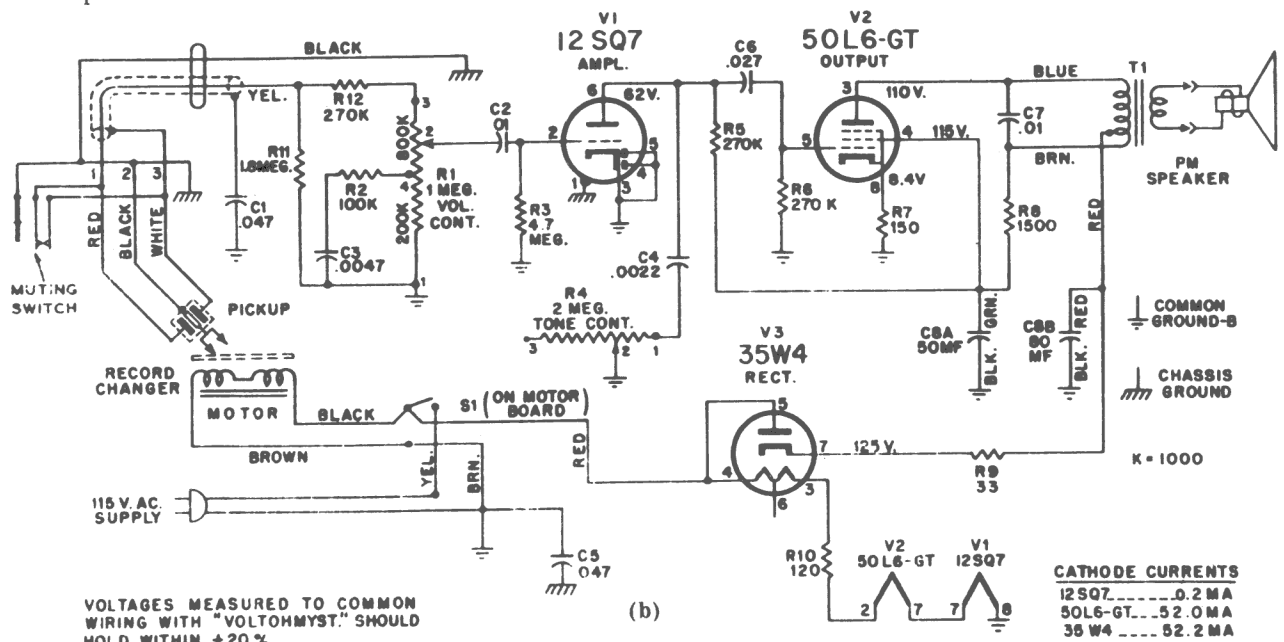
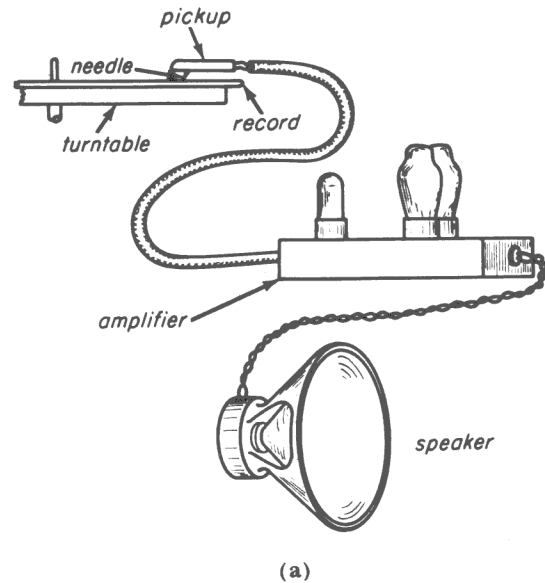
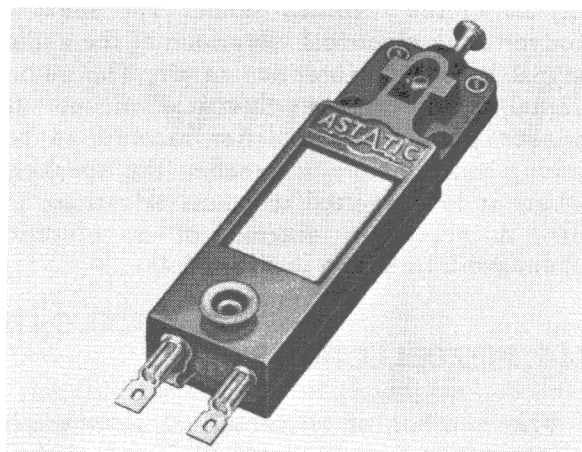
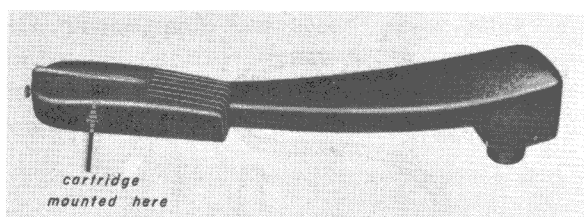


Fig. 24-4



(a)



(b)

Fig. 24-5

corresponds in strength and frequency to the strength and frequency of vibration of the phonograph needle.

Crystal Pickup. Crystal pickups are also known as crystal cartridges. Figure 24-5a shows a crystal cartridges. Such cartridge are designed to be mounted at the end of a *tone arm*, as shown at *b*. The cartridge has two electrical terminals, which connect to a thin shielded wire. The braided copper shield of the wire connects to one terminal and the insulated wire within the shield connects to the other terminal. The shielded wire is threaded through the hollow tone arm. It is this wire that feeds the audio signal into the amplifier.

Crystal pickups produce electrical signals by means of *piezoelectric* effect. The piezoelectric effect is a property of the substance called *Rochelle salt*, of which the crystal is made. The piezoelectric effect is as follows:

1. If a voltage is applied across the ends of a slab of Rochelle salt, the slab twists.
2. If pressure is applied to a slab of Rochelle salt so that the slab is forced to

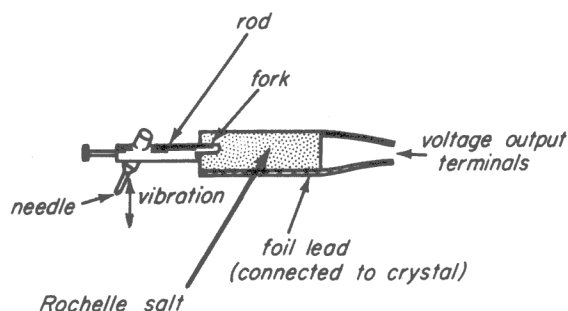


Fig. 24-6

twist, a voltage appears across the ends of the slab.

The second effect is put to use when Rochelle salt is employed as the element of crystal pickup.

Figure 24-6 shows how the crystal element is employed within a phonograph-pickup cartridge. There is a rod with a fork-shaped end within the cartridge. The fork fits over the slab of Rochelle salt so that if the rod turns (in the way an axle turns), the slab is forced to twist. The phonograph needle is attached to the unforked end of the rod. Side-ways vibration of the needle gives a twisting vibration to the rod and thus to the Rochelle Salts slab. The slab, in turn, delivers a vibrating voltage at the terminals of the cartridge. It delivers a voltage that vibrates in amplitude and alternates in polarity.

To follow the process through one complete vibration, imagine the needle to be riding in a smooth, unbent groove of a disk record. The unbent groove represents a *no sound* condition. The record is turning with the turntable, and up ahead in the grooved needle track there is a lateral bend — a bend first to the right, then to the left (Fig. 24-7). The right to left bend represents one vibration, one cycle of sound.

While the needle rides in the unbent part of the track, the Rochelle salt slab remains flat; the voltage at the cartridge terminals is zero. When the right turn of the record track arrives at the needle, the point of the needle moves to the right, the rod turns right, and the fork of the rod twists the salt slab counterclockwise. The slab begins to twist counterclockwise; the terminal voltage begins to rise from zero with a positive polarity. It keeps rising as the slab

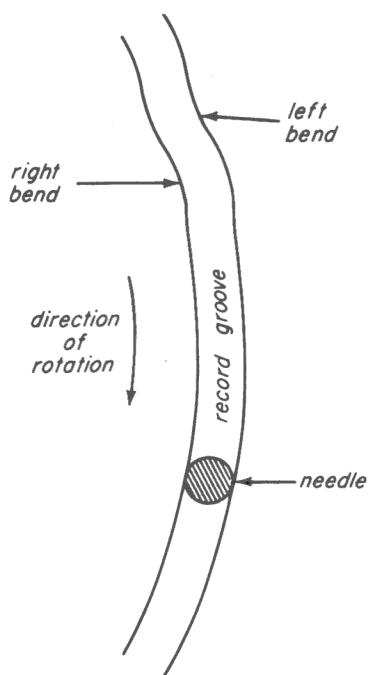


Fig. 24-7

twists, and as the bend in the record track continues to the right, and the needle point follows the track. Then, the bend in the track of the record turns back — left. The slab of salts begins to twist back towards its flat position. The terminal voltage has passed through its maximum positive value; it decreases. The voltage gets lower and lower as the slab gets flatter and flatter. Still positive, the voltage decreases until the slab is flat again. Now the voltage is zero.

Then the needle begins to follow the left turn of the record track. Its point moving left, the needle will twist the slab of salts clockwise. Voltage rises at the terminals of the cartridge. This time the polarity of the voltage is negative. The polarity of the voltage has alternated. And the negative voltage first rises, then falls — to complete the negative half of the audio cycle.

Rochelle salt crystal pickups have advantages and disadvantages. One of the advantages is high voltage output. As a result, the signal voltage from the crystal does not need much amplification to operate a loudspeaker; it can be sufficiently amplified by the audio sections of all modern radio receivers. Another advantage is good frequency response. Most crystal cartridges re-

produce most tones of most recorded music. This means that most tones are reproduced; few are not reproduced and few are distorted. All crystal cartridges do not have the *same* frequency response. Most are adequate; the more expensive are more than adequate. These last are for *high-fidelity* applications. The Rochelle salt pickup is most employed and is the least expensive of all types of pickup in common use.

A disadvantage of Rochelle salt pickups is that they are easily damaged by humidity (dampness) and heat. When soldering wires to the cartridge terminals, you must be careful not to overheat the crystal. Figure 24-8 illustrates a terminal-lug arrangement that is designed to avoid overheating during the soldering operation. The terminals shown in *a* look like ordinary solder lugs, but they are not. They are actually hollow tubes. Each hollow tube has an eye for the wire that is to be attached to it. The hollow tubes slide off the prong-like terminals as shown in *b*. Removed from the prongs, the lugs can be soldered without precaution against heat. Once soldered to the wire leads, the lugs can be slid back in place upon the prong-like terminals of the cartridge.

Ceramic Pickup. Ceramic is a name for materials produced by baking clay to form tile, porcelain, etc. Newly developed ceramic material has piezoelectric properties. This material is employed in place of Rochelle salt as the element of a *ceramic pickup*. A

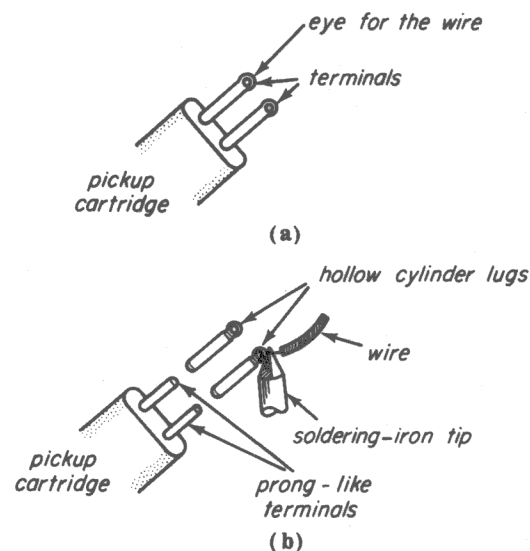


Fig. 24-8

great advantage of the ceramic pickup is its ability to withstand high temperature and humidity. Unlike Rochelle salt cartridges, ceramic pickups operate in hot and humid climates without requiring special care such as forced-air cooling and dry storage.

24-3. MAGNETIC RELUCTANCE PICKUPS

Figure 25-9 shows a modern magnetic pickup cartridge. The magnetic type of pickup has been in use longer than the crystal or any other type of pickup. It was used in the first radio-phonograph combinations. The early magnetic pickup was so heavy that the needle wore away the walls of the grooved track on the record. Records wore out quickly. The modern magnetic pickup is light in weight and it causes little wear on the record.

The magnetic pickup shown in Fig. 24-9 operates in a completely different manner than the crystal pickup. The audio-signal voltage that appears at the terminals of the magnetic pickup is generated by a changing

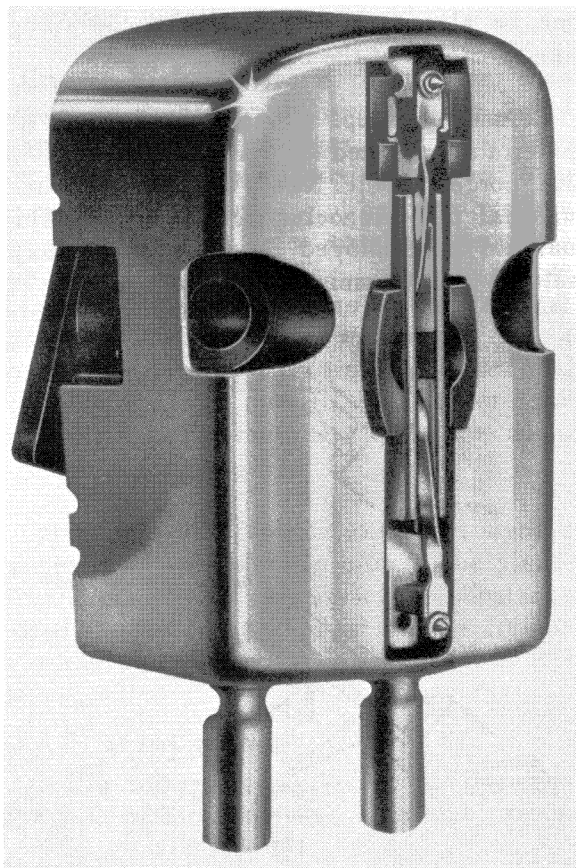


Fig. 24-9

magnetic flux in the iron core of a coil located within the cartridge. The flux changes take place as a result of the movements of the needle, which is located in an air gap in the magnetic circuit of the core. The moving needle changes the flux in the *circuit* by varying the magnetic reluctance of the gap. Thus, the pickup shown in Fig. 24-9 is called a *variable-reluctance* pickup.

Other magnet pickups use a moving coil in an unchanging magnetic field to accomplish the same thing. Since the variable-reluctance pickup is widely used with home-type record players, let's consider it in more detail.

The arrangement shown in Fig. 24-10a can be considered to be a magnetic *circuit*. Magnetic flux travels in this circuit the way current travels in an electric circuit. This flux is all within the iron conductor that connects the north and south poles of the magnet. The flux is confined to the iron because iron is a better magnetic *conductor* than the surrounding air. The magnetic circuit at *b* has an air gap in the iron *conductor*. The air gap offers *resistance* to the magnetic flux in the iron. Consequently, the strength of flux in the iron conductor *b* is less than that of the *circuit* shown at *a*. (The strength of the permanent magnet is unchanged.) Magnet *resistance* is called reluctance. The reluctance of the air gap accounts for the decreased strength of the flux in the iron *conductor* at *b*.

At *c*, a piece of iron is inserted into the gap. The more iron in the gap, the less the reluctance of the gap and the greater is the flux strength throughout the iron *conductor*. The flux strength in the iron changes as the hand moves the piece of iron in the gap. This is how flux strength can be changed by varying reluctance.

If a coil is wound around the iron conductor, as shown, the changing flux will generate an alternating current in the coil. An alternating voltage will appear across its terminals. We know this from our earlier study of the magnetic generator principle. To make a variable-reluctance pickup of our magnetic *circuit*, we have only to substitute

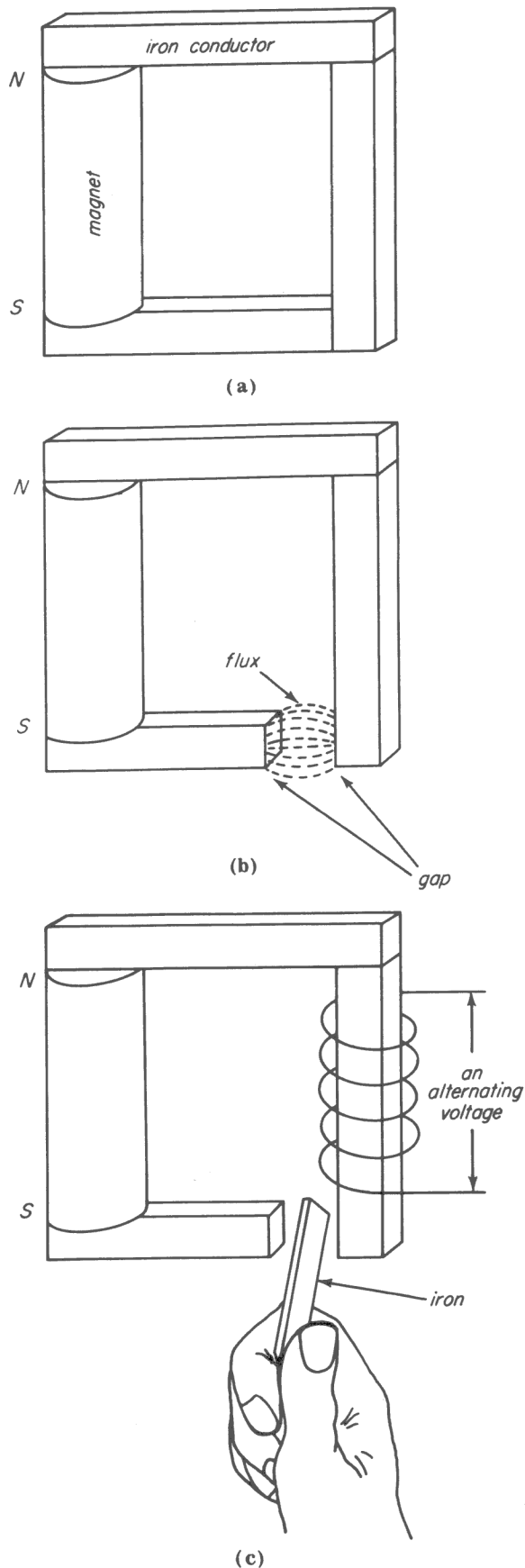
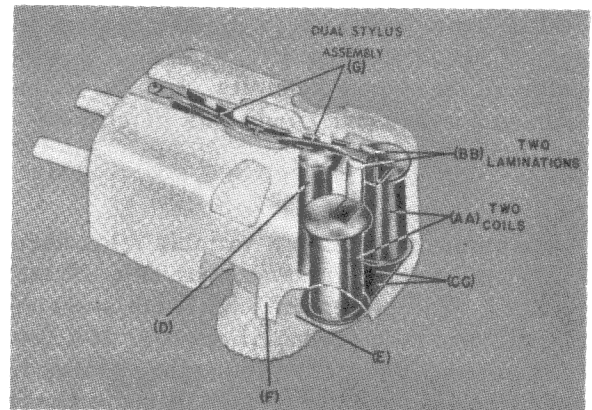
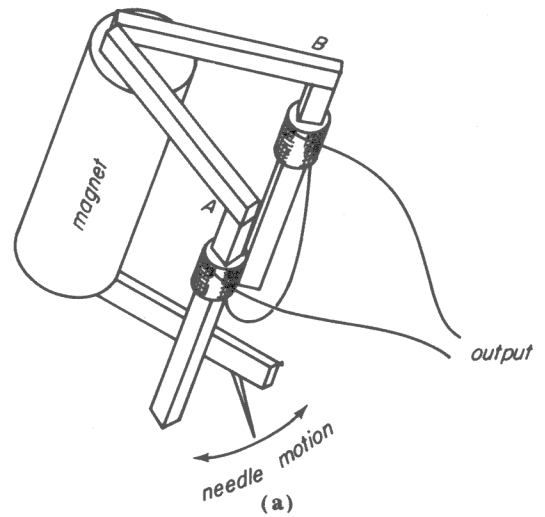


Fig. 24-10



- | | |
|--|-------------------------------|
| AA Copper wire coils wound on nylon spools | CC Yokes of same alloy |
| BB Laminations of high permeability alloy for ideal magnetic properties | D Alnico 5 magnet |
| | E Plastic base |
| | F Mu-Metal case |
| | G Dual stylus assembly |

Fig. 24-11

an iron phonograph needle for the piece of iron.

The construction of an actual variable reluctance pickup is somewhat different (Fig. 24-11a). There are two iron conductors (A and B) attached across a single permanent magnet. The phonograph needle tends to close the gap of conductor A when it moves to the left, that of B when it moves to the right. (Of course, the free play of the needle is restricted so that the needle cannot be caught and held by one of the strong magnetic poles to either side). Thus, the terminal voltage of the actual cartridge follows the *sideways* motion of the needle. It does not respond to the up-and-down move-

ment of the needle because the needle does not tend to close either gap when it moves up and down. This is an advantage of the variable-reluctance pickup.

A cutaway view of an actual variable-reluctance pickup appears in Fig. 24-11b. Another advantage of this kind of pickup is that the needle with its arm (the needle and arm together, are called a *stylus*) is the only moving part in the pickup. The stylus is light in weight; it moves easily; it easily follows abrupt bends in the track of the record, and so it reproduces rapid sound vibrations well. The cartridge shown in Fig. 24-11b reproduces up to 15,000 cycles per second. It is designed to withstand a wide range of heat and humidity, and is recommended for unusual conditions of climate — hot, cold, wet, and dry.

The output voltage of a variable reluctance pickup is not as great as that of a crystal pickup. Therefore, an additional stage of amplification—a preamplifier (Fig. 24-12)—is required to permit the reluctance pickup to operate a loudspeaker through an audio amplifier of the kind found in home-type radio receivers. The voltage output of reluctance pickups is much greater at high frequencies than at low frequencies. The preamplifier strengthens the low frequencies more than the high frequencies so that all frequencies emerge equally strengthened; the preamplifier equalizes.

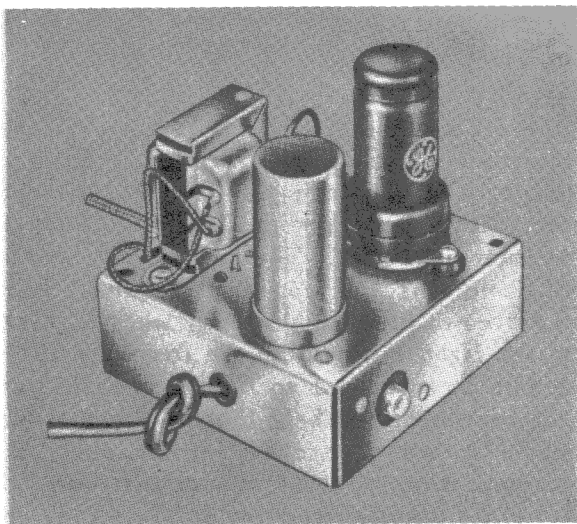


Fig. 24-12

Equalization. Pickup output voltage has to be equalized before it arrives at the loudspeaker. This is because the output voltage delivered by the pickup is not the same for audio tones having different frequencies but recorded at the same amplitude. For such tones, piezoelectric pickups deliver a large output voltage at low frequencies and a low output voltage at high frequencies. The opposite is true for the magnetic generator pickups, which for such tones, deliver a low output at low frequencies and a high output at high frequencies. To understand, we will have to consider the frequency-containing characteristics of records together with the frequency response characteristics of pickups.

A piezoelectric pickup responds to the width of the bend in the record groove. The farther the track bends away from its unbent (no sound) position, the greater is the output of a crystal. The output voltage of a crystal element is greatest when the amount of twisting pressure that is applied to it is greatest. This, of course, is when the needle has followed the record groove to the peak of its bend. On the other hand, the output of the magnetic pickup is greatest when the sideways swing of the needle is fastest—when the needle is moving fastest, not when the needle has moved the most. This is in line with what you know about magnetic generators. The voltage induced across a conductor wire moving in a magnetic field is greatest when the wire is moving fastest. So, the output of magnetic pickups is greatest when the bend in the record groove is sharpest, not where the bend extends farthest from its unbent location.

In order to understand how the response characteristics of the two types of pickup affect the pickup outputs that result from standard records, we must know how standard records are cut. There are two possible ways to cut records. Assume that a record is being cut to represent a range of tones extending from the lowest to the highest audio frequency. Also, assume that the loudness of all the tones is equal. The loudness of the sounds being recorded is equal at each audio frequency. Then, (1) the recording equipment can be arranged to cause the

record groove to bend an equal distance from normal at each frequency — in which case the bends in the groove become sharper as frequency increases. Or, alternatively, (2) the sharpness of groove bend can be held constant — in which case the distance that the groove bends away from normal is greatest at the lowest frequency and decreases as frequency increases.

In the first method, output from a crystal pickup will be constant at all frequencies, that from a magnetic pickup will be lower at low frequencies than at high frequencies.

In the second method, output from a magnetic pickup will be constant at all frequencies while that from a crystal pickup will be higher at low frequencies than at high frequencies.

The second method (constant velocity) represents the method of recording which is an unaltered copy of nature's way of making sounds — if two tones, one high pitched, and one low pitched, have the same loudness, the amplitude of the vibrations of the low pitched tone will be greater than the amplitude of the high pitched vibrations. This can be seen by watching two piano strings vibrate. Strike middle C and then strike a low note with the same intensity.

But constant velocity, nature's way, would cause the recording stylus to swing so widely, at frequencies below 500 cps, that it would cut into the next groove.

In fact, wide bends of the record groove that represent low tones come close to cutting into the next groove of the record. The wall of record material separating a groove adjacent to a widely bent groove is very thin. It is at this point that the wall occasionally breaks down. When this happens, the phonograph plays the same circle of track over and over; the same sound is heard over and over again.

The amplitude must not be permitted to swing that far. Therefore, constant velocity, the rate at which the stylus normally moves, is curbed in the region of the bass frequencies, and constant amplitude is substituted. In other words, the sidewise speed of the stylus is slowed in proportion to the lowness of the tone.

This means that low tones are recorded at less than nature's level, and will sound weak when played back, unless a pickup is used which reproduces low notes more efficiently than high. This is a crystal pickup. A magnetic pickup reproduces low notes less efficiently than high. Therefore, its output, very weak in the bass region, must be boosted, or made equal to normal — equalized — in order for the reproduced sound to seem normal to our ears.

Actually, the two methods are combined in the cutting of standard records. Assuming all the sounds being recorded have equal loudness the standard cutting procedure holds the distance of groove bend constant for the very lowest frequencies and holds the sharpness of groove bend constant for higher frequencies. As a result, the output voltage of crystal pickups is high at the very lowest frequencies and it drops off as frequency increases. The output voltage of the magnetic pickup is low at the low frequencies, high at the high frequencies.

The groove bends most sharply at high frequencies because there are more bends per inch. It is for this reason that the output of magnet pickups is greatest at high frequencies.

Equalization of a crystal pickup is a simple matter. The output of the crystal is so great that cutting down the low-frequency output will result in an output that is fairly equal for all frequencies and still strong enough at all frequencies to operate a speaker through an ordinary radio and audio amplifier without a preamplifier.

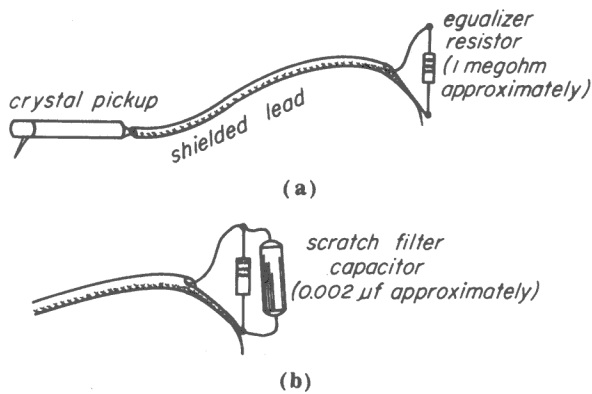


Fig. 24-13

The low-frequency output of a crystal can be cut down by loading it with a resistor of about one megohm (Fig. 24-13a). The output of a crystal with open-circuited terminals is high at low frequencies, and that of a crystal with a resistor across its terminals is more nearly equal to the high-frequency output. The smaller the value of the resistor, the more high-frequency output. However, the strength of output, especially low-frequency output, decreases excessively when the resistor becomes too low in value.

The crystal's load resistor is its equalizer. Often, a low-value capacitor is to be found across the resistor (Fig. 24-13b).

This is known as a scratch filter. It acts to restrict the response of the crystal to very high frequencies by shunting high-frequency voltage to ground. Since scratch is high-frequency noise, the presence of the capacitor results in less scratch. It also results in less high-frequency sound. To a degree, this is desirable because there is too much high-frequency sound on the record to begin with. The manufacturer put it there to drown out the scratch. This is called preemphasis, and the scratch filter is sometimes called a high-frequency de-emphasis filter.

In the case of the magnetic pickup, the low-frequency output is so low that equalization by reduction of the high-frequency output to match the low-frequency output would result in an excessively low total output. Instead, the low-frequency output must be built up. To do this requires an amplifier—a preamplifier—that amplifies low frequencies more than high frequencies. The schematic diagram of a preamplifier for a variable-reluctance pickup is shown in Fig. 24-14. Audio signal originating in a magnetic pickup passes through the preamplifier before it reaches the main amplifier. An audio signal from a crystal pickup can be applied directly to the main amplifier.

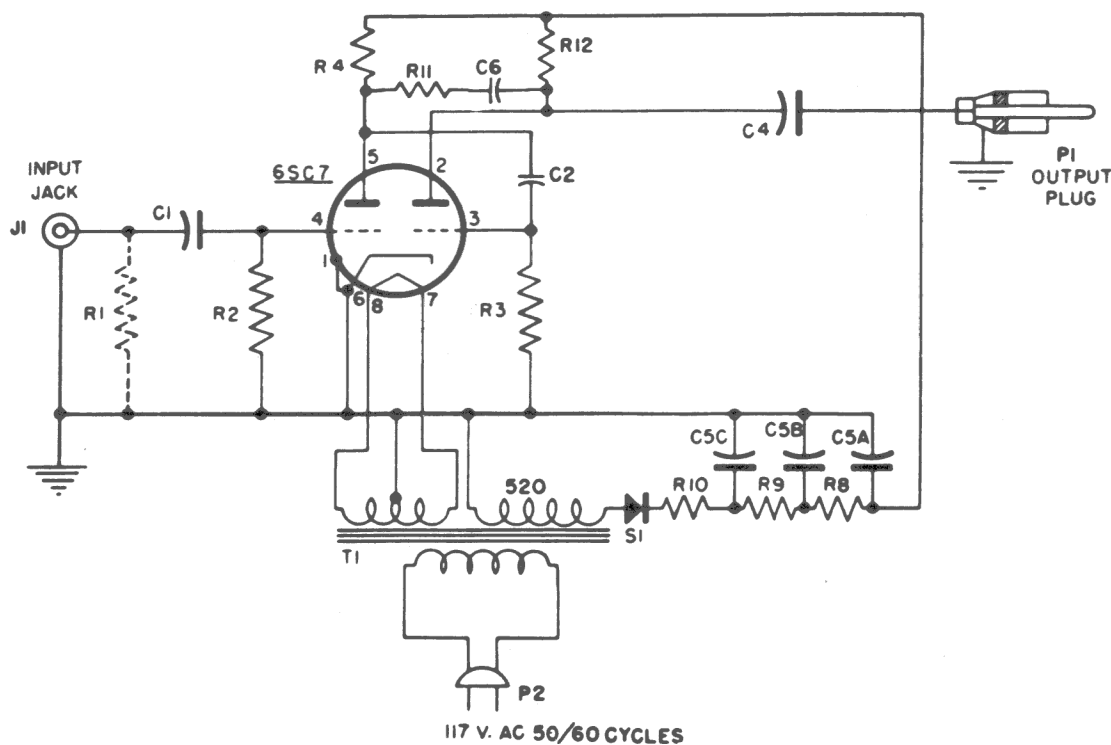


Fig. 24-14

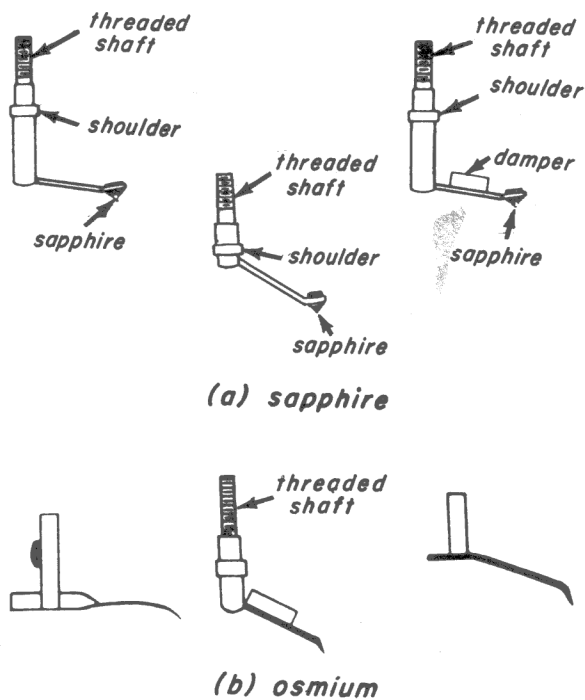


Fig. 24-15

24-4. THE STYLUS

Audio signals are generated in a pickup according to the movements of the stylus. Stylus is another name for phonograph needle. More exactly, a stylus is the modern kind of needle, which is something more than a pointed shaft of steel. Figure 24-15 shows a variety of modern phonograph needles.

Most modern phonographs employ a stylus of the kind called a permanent needle. These do not have to be replaced often. This is possible because the points of such needles are made of a hard substance that is not easily worn out of shape. Needles wear by being scraped against the record over long periods of time. Although the point of a phonograph needle feels sharp to touch, it is actually rounded. Under a magnifying glass, it appears as shown in Fig. 24-16a. It is shaped to ride smoothly in the record groove and not damage the groove. After it has become worn, the needle point appears

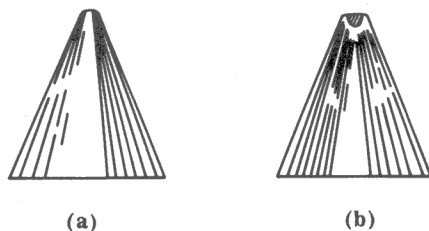


Fig. 24-16

as shown at *b*. In this condition, a needle is capable of damaging the record groove because of its sharp edge.

A very hard material is best for phonograph needle points because hard material is least inclined to wear away; it retains its rounded smooth shape longest. Diamond-tipped needles are best and most expensive. Other materials employed to form phonograph-needle points are hard steel, osmium, and sapphire.

Some pickups are provided with a chuck and thumb screw arrangement to hold the needle (Fig. 24-17a). With these, needle replacement is a simple hand operation not requiring the use of tools. Other pickups have their permanent needles mounted in such a way that replacement requires the use of tools (Fig. 24-17b). There are many needle chuck designs. Designers try to make the

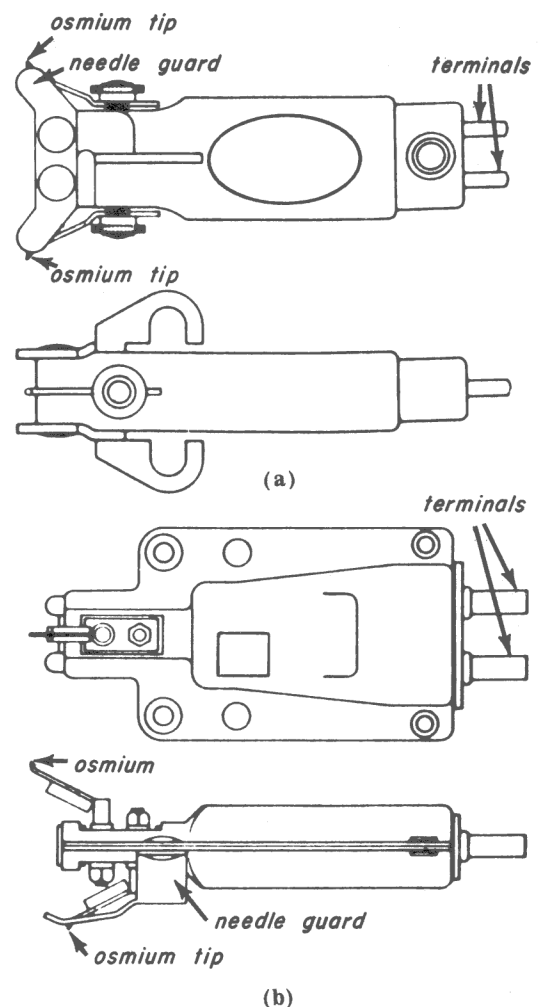


Fig. 24-17

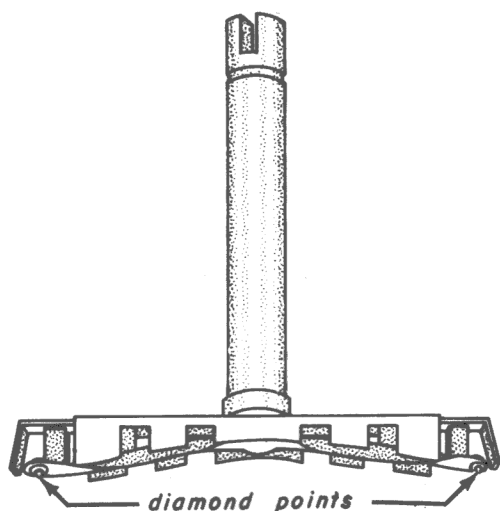


Fig. 24-18

vibrating system (the stylus and the chuck) as light as possible. The lighter the vibrating system the better it follows bends in the record groove.

The point of a phonograph needle should fit correctly in the groove of a record. Needles may be obtained to fit either the wide grooves of 78 rpm records or the *microgrooves* of 33-1/3 and 45 rpm records. The correct needle point size for 78 rpm records is 0.003 inch, and for microgroove records it is 0.001 inch. A pickup designed to play all kinds of records must have provision for two needles in its vibrating system—one of each size. The pickup shown in Fig. 24-17 has the 0.001-inch point protruding from the top side of the cartridge while the 0.003-inch point protrudes from the bottom and contacts the surface of a record. To use the 0.001-inch point, you rotate the cartridge on its tone-arm mount so that the top and bottom sides are interchanged. This is called a *turnover* cartridge. The reluctance cartridge that was described previously has the two diamond points mounted on a single stylus (Fig. 24-18). The desired size of a point is chosen by rotating the stylus on its vertical part so that one or the other point contacts the record surface.

24.5. THE RADIO-PHONOGRAPH COMBINATION

In a radio-phono combination, the output of the pickup is fed to the amplifier and speaker of the radio. Figure 24-19a shows a record player attachment consisting of a



(a)



(b)



(c)

Fig. 24-19

motor-driven turntable and a pickup (no amplifier or speaker) that is designed to be attached to a radio receiver. A record player may be built into the radio cabinet (Fig. 24-19*b* and *c*).

The sound goes from the pickup to the amplifier over the two wire leads from the output terminals of the pickup that connect to the outer end terminals of the radio volume control.

The Radio-Phono Switch. In radio-phonograph combinations, it is desirable to have the sound signal from the radio station disconnected from the radio's audio amplifier when the sound signal from the phonograph is connected so that both sounds will not be heard at the same time. The radio-phono switch switches in the desired signal. Table-model radios intended to receive the output of a record player attachment and radio consoles with built-in phonographs have radio-phono switches. A radio receiver can be considered to have two major sections: an audio-amplifier section and a section that picks up the signal from broadcast stations (Fig. 24-20*a*). The volume control is at the electrical junction of the two sections.

When the operator of the set wishes to hear a radio broadcast, he turns the radio - phono switch to radio position. In order to hear the phonograph, he switches to the phono position. An audio signal representing the broadcast stations sound is normally delivered to the volume control. The selector switch disconnects the broadcast audio from the volume control and, in its place, applies the audio signal from the phonograph pickup (Fig. 24-20*b*).

Although there is usually a motor on-off switch on the motor board of the record player, the radio-phono selector switch often controls the motor, too. In the radio position, it turns the motor off. In the phonograph position, the selector switch may perform the additional function of removing B+ voltage from the station pickup tubes of the radio. The schematic of a radio-phonograph combination appear in Fig. 24-21.

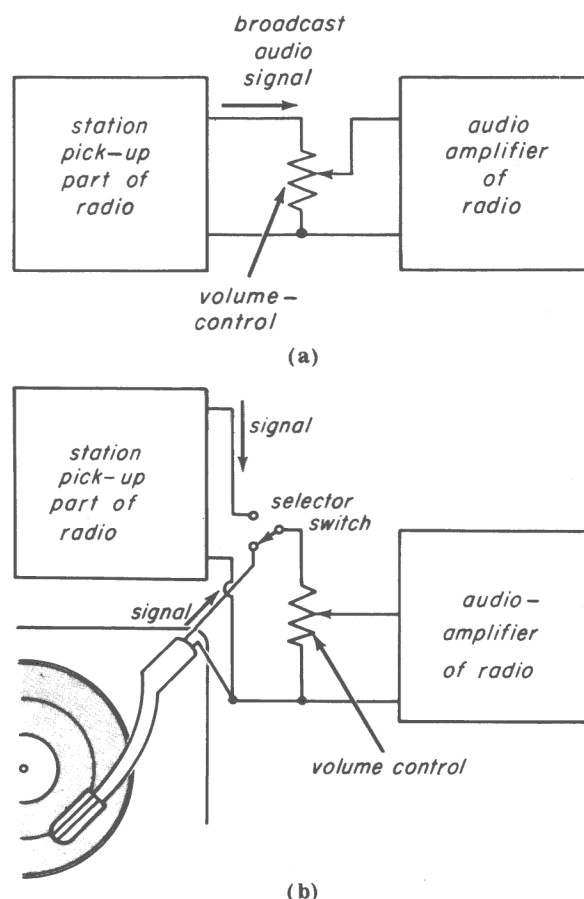


Fig. 24-20

24-6. SERVICING THE RADIO-PHONOGRAPH

The following list of complaints covers just about everything that can go wrong with the phonograph part of a radio-phonograph combination (excluding the record-changer mechanisms, which are not taken up in this lesson):

1. Phonograph not operating
2. Phonograph operates but sounds weak
3. Phonograph operates but has hum
4. Phonograph operates but has rumble
5. Phonograph operates but has wow

Phonograph Not Operating. The radio phonograph that is shown schematically in Fig. 24-21 is typical of the combinations under discussion. Where the radio in such a combination is operating but the phonograph produces no sound, the cause is usually easy to find. A crystal pickup need only be connected to a properly functioning audio ampli-

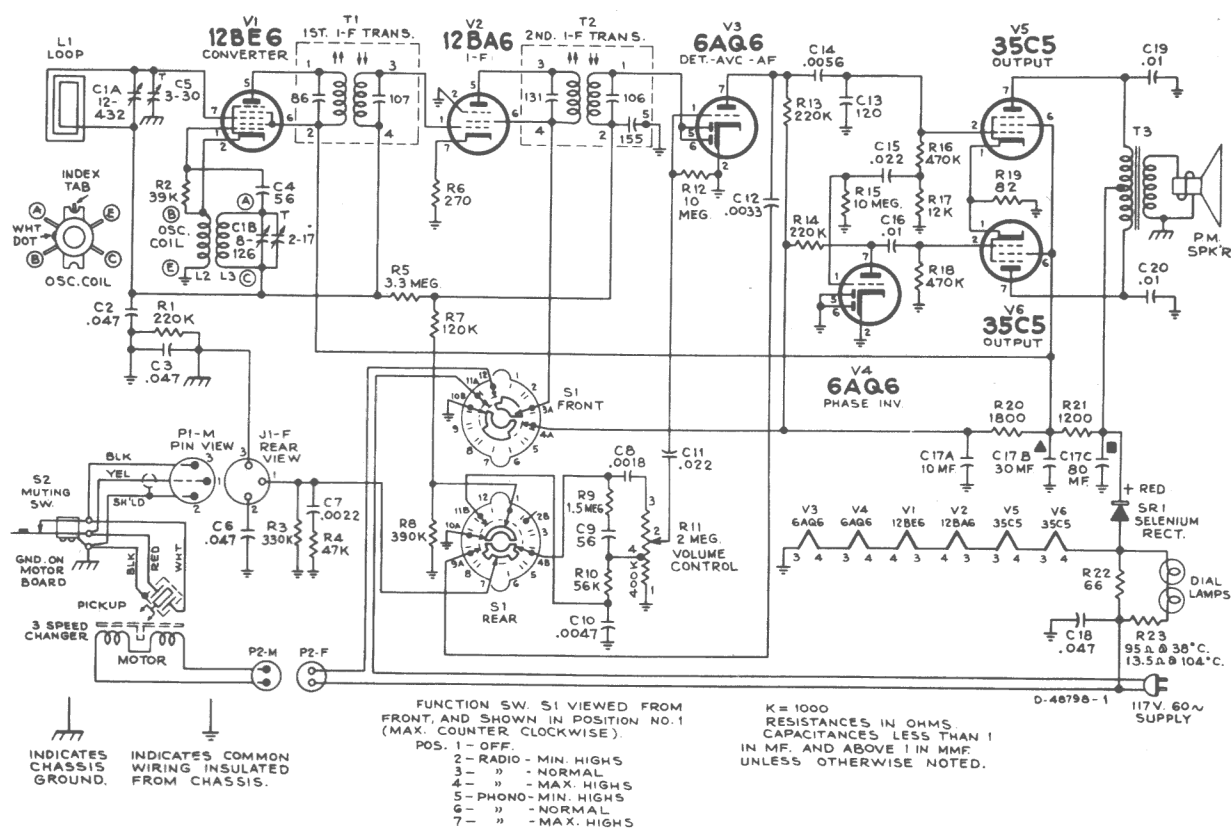


Fig. 24-21

fier to produce sound. The amplifier must be functioning for the radio to play, and so the trouble must be located in the phonograph. There are a few possible causes for failure of the phonograph to produce sound. These are:

1. Defective phonograph pickup cartridge
2. Defective wiring, from crystal cartridge to audio volume control.
3. Defective selector switch.

The pickup produces no sound with a record turning against its needle. To know whether or not the pickup is at fault, test the remainder of the circuit from pickup output terminals to loud speaker. Do this by touching your finger to the hot output terminal (the terminal that is not grounded to the braided copper shield of the output lead). When you do this, you apply a stray sixty-cycle audio signal from your body to the volume control through the shielded lead. With the volume turned up, a sixty-cycle hum

sound should be heard from the speaker. If so, the pickup is defective. The remainder of the circuit tests good—it accepts and reproduces the sixty-cycle signal. Of course, you would notice a break in the *hot* output lead at the pickup terminal if this were the cause of trouble.

If no hum is heard, the wiring from cartridge to volume control is defective. The wiring might be opened; it might be shorted to ground. Circuit-trace the wiring with your ohmmeter. Test for continuity from the *hot* terminal of the cartridge to the volume control, then to the moving contact of the selector switch, then to the fixed contact of the switch, etc. A lack of continuity indicates an open circuit. To test for a short circuit, connect your ohmmeter between the *hot* wire of the output lead and its shield. When the meter (R x 1 scale) indicates a short, it is usually the lead itself that is shorted. A break in the insulation allows the inner wire to contact the braided copper shield. Shielded wire for replacement purposes is readily available at parts wholesalers.

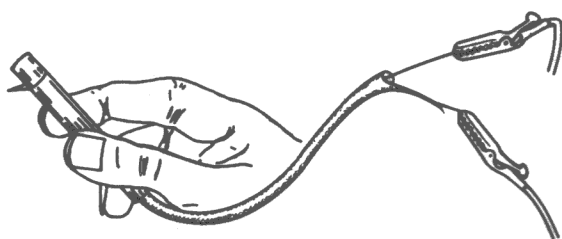


Fig. 24-22

Phonograph Sounds Weak. Low volume is usually the result of a defective pickup. To make sure, substitute a pickup known to be good. A *test cartridge* is a handy thing to have for this purpose. Connect clip leads to a spare cartridge, as shown in Figure 24-22. It is not necessary to mount the test cartridge in the tone arm while performing a test. Simply hold it lightly against a spinning record. The clips should be attached to the ends of the shielded lead in the tone arm.

Phonograph Operates With Hum. Where no hum is heard while the radio plays, hum that heard with the sound from the phonograph is usually stray 60-cycle signal, picked up as it is when you touch your finger to the input of an amplifier to test it. Then your body forms a large unshielded conductor connected to the input of the amplifier. The usual cause of accidentally picked up hum is a discontinuity in the braided copper shield that covers the long lead connected to the input of the amplifier. The shield may accidentally disconnect from chassis due, for example, to a poorly soldered connection. It no longer shields the inner wire. This does not prevent the pickup's audio signal from reaching the volume control, but hum signal reaches the control along with the audio. The hum is picked up on the long and now unshielded lead to the control. There is no hum while the radio plays because, with the selector switch in the radio position, the offending lead is disconnected from the volume control.

Phonograph Operates With Rumble. Sometimes a rumbling noise is heard together with the sound produced by a phonograph. Both the wanted sound and the rumble sound come from the loudspeaker. The rumble is

caused by vibration from the motor that travels along the motor board to the pickup. The pickup is sensitive to vibration; it converts the rumbling vibrations to an audio signal just as it converts the sound vibrations of the needle to audio. Record players are designed so that the rumble of the motor is not excessive. Rumble can usually be heard with the volume control set at maximum.

There is always some rumble, but normally the wanted sound drowns it out. When rumble is excessive, you may be sure that some rubber or spring mounting cushion for motor or motor board is broken or out of place, or that the motor shaft is not properly lubricated and is shaking as it spins in its dry bearing. Spring mountings are often screwed down tight for shipping purposes (Fig. 24-23). Be sure that these are loosened to provide the necessary cushioning while the phonograph is in use.

Phonograph Operates With Wow. Place the tone arm of a phonograph in its position on the surface of a record and, with the motor switched off, give the turntable a spin by hand. The record goes around at a slow irregular speed and, no matter what sound is recorded on the record, what proceeds from the loudspeaker sounds like a voice saying "wa, wa, wow." Appropriately enough, *wow* is the name given to sounds which result whenever a phonograph is playing with slow, irregular variations in the speed of the turntable. The pitch of the sound varies with the variations in turntable speed. *Flutter* is the name for fast variations in the pitch of recorded sound resulting from fast variations in the speed of the turntable.

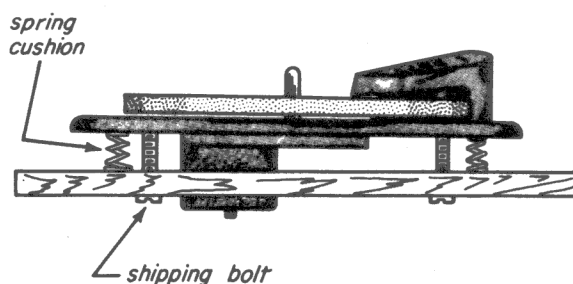


Fig. 24-23

Variations in the turning speed of a record occur if the record slips on the turntable, even though the turntable is rotating at a constant speed. When the speed of the turntable is unconstant, slippage and off-center wheels in the mechanism that couples motor to turntable are fre-

quently at fault. Slippage is usually the result of the presence of lubricating oil or grease in the friction-drive system on the rim of the turntable, the rubber-tired idler wheel, or the motor shaft. A flattened drive wheel is another fault that causes variations in turntable speed.

